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Group Interaction on Interactive Multi-touch Tables by Children in India

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ABSTRACT

Interactive tables provide multi-touch capabilities that can enable children to collaborate face-to-face simultaneously. In this paper we extend existing understanding of children's use of interactive tabletops by examining their use by school children in a school in Delhi, India. In the study, we explore how the school children exhibit particular types of collaboration strategies and touch input techniques when dealing with digital objects. In particular, we highlight a number of behaviours of interest, such as how the children would move the same digital object on the table together. We also discuss how the children work in close proximity to each other and dynamically organize their spatial positions in order to work together, as well as establish territory and control. We go on to examine some of the finger-based interaction and manipulation strategies that arise in these contexts. Finally, the paper considers the implications of such behaviours for the deployment of tabletop applications in these particular educational contexts.

Categories and Subject Descriptors

H5.3. Group and Organisation Interfaces.

General Terms

Human Factors.

Keywords

Multi-touch interactive tables, children, multi-finger interaction, collaboration and India.

1. INTRODUCTION

There has been a growing interest in exploring multi-touch interactive tables in educational contexts. Interactive tables provide a platform for children's peer group learning, enabling all children to participate simultaneously in the interaction and be visibly aware of each other's activities and learning. In addition, they enable the direct manipulation of digital objects that can be a key component of exploratory learning of a particular domain of study [2]. Many of the studies surrounding children and multi-touch tabletops are based on participants from the Western world (e.g. Mansor [6] and Harris et al. [3]) but we have very little understanding on how children in other countries and cultural settings interact with digital objects, such as those on interactive tables. Within these settings, there may be different social protocols determining how task-based collaboration is organised

and mediated through conversation, interaction and arrangement of artefacts. For example, in studies of educational settings in rural India using traditional PC set-ups, there is a tendency for group learning to be dominated by the oldest, brightest and richest children [10]. Similarly, gender differences are apparent in the way that collaborative educational tasks are organized in the settings with girls making a more conscious effort to share as well as being more likely to defer control [10]. Pawar et al. [10] argue that providing shared control of these systems (e.g. through the provision of multiple mice) can facilitate the engagement of children working together on interactive educational software. Within developing countries, the primary concerns are rarely about the facilitation of collaboration *per se*, but about the very practical issues of financial cost in having to share resources. Within this context, it is important for us to understand shared tabletop usage not just in Western cultures, but also within the context of the particular concerns of developing countries. To this end, we present a study of children from a school in Delhi, India engaged in a peer-learning task around an interactive table.

2. STUDY DESCRIPTION AND ANALYSIS

We conducted an observational study over three days to explore how children interact with digital objects on interactive tables. We recruited 83 pupils (aged between 11 and 13 years) from a girls' school in Delhi, India. The participants were divided into 15 groups of 4 to 6 pupils. All groups were self-selecting and consisted of children from the same class who were thus familiar with working together on group learning tasks. Each group was free to choose when to attend a session during school hours. In terms of technological exposure, the school has one computer room consisting of less than 10 PCs. Lessons using the computer are generally held once a week in a shared usage (i.e. one pc to many children due to the limited number of availability).

Our table was a custom-built FTIR table [4] (90cm x 90cm and 76cm high with a projection of 72cm x 48cm (using an NEC NP410 projector). A Point Grey Dragonfly2 infrared camera tracked user interactions. The task applications were created using Adobe Flash and Action Script 3. The table was configured with one of two interaction techniques: (1) direct touch: a multi-touch platform where multiple users could interact directly with digital objects; (2) pantograph: finger movements in the pantograph area are amplified to create larger cursor movements on the surface, allowing digital objects to be reached without stretching across the table [9]. The table was situated in the school computer room for the duration of the study.

Two types of collaborative learning activities were deployed: (1) spider diagram: similar to a mind map in which a topic is investigated and explored by visualizing associations and relationships between key concepts; (2) classification: to classify and group twenty elements (images and concepts) of a topic according to category. Each category was represented by a square

yellow box. The layout of the elements was scattered in a circle around the centre point of the surface, providing equal access to the elements for each participant. The spider diagram and classification activities were based on the “*Photosynthesis*” and “*Animals*” both topics from the Indian National Curriculum. Further description of the interaction techniques and activities can be found in our previous study [4]. The activities and techniques add ‘richness’ to our study.

During the session, children were exposed to both interaction techniques and learning activities. After each session we would switch the order of the conditions randomly. Video was used to record the physical and verbal behaviour of all the groups performing the activities. Our analysis draws on a detailed examination of the video recordings and focuses on the collaborative achievement of the tasks. We articulate the interaction details of how gestures, talk and action are produced, coordinated, made visible and understood with respect to the table and on screen objects. We used evidence-based interpretation to illustrate our findings and observations following the methodology of existing literature on interaction analysis [5]. The forms of evidence used include sequence of video frames or vignettes depicting the children’s interaction with digital objects. Due to the nature of our sample population, it is worth noting that our results are based on a single gender observational data.

3. GROUP ACTIONS

We observed two group working strategies employed by the children when creating a spider diagram using the direct touch technique. First, the children were seen moving the same object together. In the following example, five children in Group 14 are trying to organise the relationship between *chloroplasts* and *tree* (see Figure 1a and Table 1). Three children successfully coordinate the relationship and location between *tree* and *chloroplasts* – concurrently. The interaction starts with P5 verbally suggesting chloroplasts be placed close to the tree. This was supported by her hand actions: she points to chloroplast, then moves her arm to point towards the tree (28:56). P3 responds to P5’s suggestion by touching chloroplast and then glances towards P4 while verbally requesting P4 to move the chloroplast towards the tree (29:00). One second later, P4 touches and moves the chloroplast from the middle of the table (the current position) towards the direction of the tree located at the far right hand side of the table (Figure 1a). During this period, P1 can be seen glancing and looking towards P4’s unfolding actions. P1’s attentiveness can be seen in her smooth integration into direct collaboration: at 29:02, P1 stops working on her own keywords and joins P4 in moving the chloroplasts. Both of their eye gazes constantly moved between the chloroplast and tree tracking the eventual route of the path that the chloroplast was then moved through. While P1 and P4 were moving the chloroplast, their action was visibly observed by P2 (P2’s gazes were directed towards the chloroplasts) for a couple of seconds before joining in with P1 and P4. For a period of two seconds (29:04-29:06), the three children touched and moved *chloroplasts* simultaneously (Figure 1a). Together, and without appearing to show any conflict in their actions, they choose the path of moving *chloroplasts* to the end of the right side of the tabletop, where *tree* was located. As they did so, all of their gazes continuously shifted between *chloroplasts* and *tree*. No one child visibly attempted to lead this action, either by pulling or pushing chloroplasts against the direction of the others. As *chloroplast* reached *tree*, P1 and P4 released their fingers, while P2 continued the action (29:06). So, this collaborative interplay ended with P1 and P4 voluntarily releasing their touch on the object and they watched P2 as she

continued to position *chloroplast* just underneath *tree*. The children then moved on to work on other keywords.

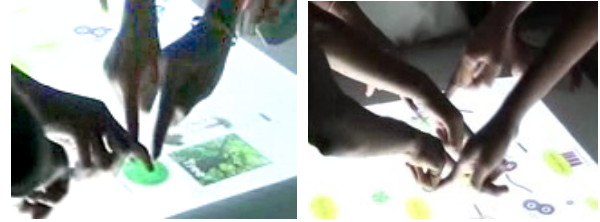


Figure 1a (left). Three students touching and moving *chloroplasts* towards *tree* simultaneously. Figure 1b (right). All five members of Group 11 were seen working within close proximity of each other

28:56	P5: “Chloroplasts should go from here to here!”	P5 pointed to <i>chloroplasts</i> (located in the middle of the tabletop), then moved her arm and pointed to <i>tree</i> (located at the right side of the table). P5 worked on another object.
29:00	P3: “Move this!”	P3 touched <i>chloroplasts</i> while glancing at P4.
29:01		P4 touched <i>chloroplasts</i> while P3 released her touch on the object. P4 then moved <i>chloroplasts</i> towards the direction of <i>tree</i> .
29:02		P1 glanced at P4, then stopped working with keywords around the <i>tree</i> . P1 also touched and moved <i>chloroplasts</i> together. P2 watched P1 and P4.
29:04		P2 touched <i>chloroplasts</i> and moved it together with P1 and P4 towards the <i>tree</i> (Figure 1a).
29:06		P1 and P4 released <i>chloroplasts</i> and pulled their hands towards their bodies (<i>chloroplasts</i> was now close to <i>tree</i> as shown in Figure 1a).
29:08		P1 and P4 watched P2 continue to move <i>chloroplasts</i> and adjusted its position just underneath the <i>tree</i> .
29:10		P2 released her touch on <i>chloroplasts</i> . The students continued working on other keywords.

Table 1: Children interacting with each other in organising the relationships between *tree* and *chloroplasts*.

The interaction of moving the same object simultaneously is curious given that any one child could have moved the object. It is also curious no obvious verbal or non-verbal invitation led to the children touching or moving *chloroplast* together. Based on P5’s verbal suggestion and hand movement at 28:56, the children all knew that *chloroplast* could be connected to *tree*. The simultaneous movement of *chloroplast* by the children was a demonstrable means of them all showing their understanding of this answer. That is, it was not simply a question of getting the answer right, but also important that they all showed their understanding of this to each other. Multi-touch, then, played an important role in enabling this demonstration.

Let us now consider how the children proximally organised themselves to work together in ‘crowded conditions’ (Figure 1b). In the following interaction from Group 2, two children were creating relationships around *leaf* on the left side of the tabletop before others started to work within close proximity of each other:

02:46		P2 rotates <i>leaf</i> .
02:48	P2: “What’s this?”	P3 was moving <i>chlorophyll</i> beside <i>leaf</i> when P2 then pointed to it and exclaimed.
02:50	P2: “I	P2 took <i>chlorophyll</i> and moved it towards

	want to move this here!"	<i>tree</i> . P1 was moving <i>oxygen</i> . P4 and P5 were moving <i>H2O</i> and <i>sun</i> respectively. See Fig 1b.
02:53	P5: "I don't think this goes there!"	P2 drew line from <i>chlorophyll</i> to <i>leaf</i> . P3 drew line from <i>chlorophyll</i> to <i>photosynthesis</i> . P5 moved <i>sun</i> towards herself. P1 and P4 rotated and moved <i>oxygen</i> and <i>H2O</i> respectively towards themselves.
02:57		The children continued to work on other keywords

Table 2: Children working together in close proximity

Two separate activities can be seen in Table 2 scenario. P2 and P3 were creating relationships around *leaf* (02:46-02:53) through its movements and interactions with other objects, while the other members were moving and rotating various keywords around (2:50-02:57). As shown in Figure 1b, those activities were performed within close proximity of each other for about 10 seconds with occasional crossing pathways and finger contacts. For example, P1's index finger crossed underneath P5's fingers when she was moving her keyword. Although the children moved objects and drew lines all within close distances of each other (02:50-02:53), it is possible that working in a 'crowded area' of each other contributed towards the group's cohesiveness and engagement with the task and/or each other: empirically, we can see that they are clearly very aware of each other's actions. Here, such engagement may be due to the interactive table allowing them to view what each other was doing whilst performing their own individual activities. This interactive format is also aided by the fact that the children's gazes were constantly directed between the middle of the tabletop (where P1, P4 and P5 were manipulating other keywords) towards the left hand side of the tabletop (where P2 and P3 were working on *leaf* and *chlorophyll*), making them more alert of each other's activities. This type of behaviour was seen throughout the task i.e. the children would join their activities together in any small space within the tabletop area for a few seconds, dispersing and then join back together; this appears to be a 'normal' working strategy for them.

4. MULTI-FINGER TOUCH TECHNIQUE

We frequently observed how students used multi-finger touch input techniques when they: 1) moved digital objects, 2) drew lines and 3) used the pantograph to select and move objects. The first example of this can be seen in Group 2 in Figure 2a. Here, P1 moves an object with her middle finger. Next to her, P2 touches and moves an object using all of her five fingers.

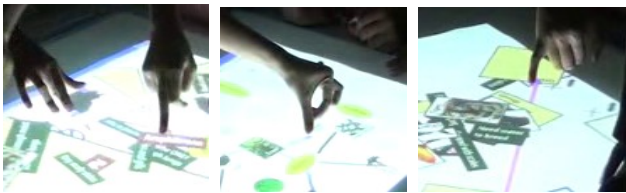


Figure 2a (left): single and multi-finger interactions. Figure 2b (middle): drawing a line between keywords with thumb.

Figure 2c (right): selecting object with little finger

Another non-typical form of touch exhibited by the children occurred when they used their thumbs to move objects or draw lines (e.g. Figure 2b), rather than the more typical use of an index finger (what we might normally consider as the main interaction finger). When using the pantograph, the children used what might seem peculiar touch input techniques with their thumbs, middle fingers and little fingers to select and move objects (Figure 2c). This is notable: there are very few instances of the multi-finger touch input in the literature other than the use of the index finger

as the main interaction technique. We speculate it as a "marked" form of interaction that can help to draw people's attention to what the children were doing. Another possibility based on our observation is that the children tend to use various hand movements and gestures when they talk with each other. It was as if using those particular hand actions, in concert with their talk, helped to express and punctuate the presentation of their ideas further. Perhaps the multi-finger touch input is a form of expressing themselves when interacting with the digital objects. What we can say with some certainty is that we cannot expect non-Western users to interact solely with index fingers in collaborative interactions on digital tabletops.

5. DISCUSSION & IMPLICATIONS

5.1 Group Actions

Observing more than one person moving the same object simultaneously is a peculiar type of behaviour. In a study by Marshall et al. [8], a tourist planner application was designed with the intention of encouraging groups of tourists to plan their activities together. However their findings showed that group members often did not perform the activities collectively - subgroups were seen where members tended to work individually on other items, rather than collaborate with each other. Although their findings were based on adults' behaviours, it is possible that similar effects may prevail in children. Yet, in this study, we saw group activity happening frequently in *all* of the groups observed in India, perhaps demonstrating a need to all be equally responsible for an action. What is of interest in this finding is that our applications were not purposely designed for such group behaviours and yet we saw the moving of objects performed simultaneously by two, three or more children. Notable was the coordinated nature of the movement and direction with no apparent tug-of-war in which one person would pull the object one way and another person dragging it in a different direction. It was as if there was no leader during that moment and that everyone had equal access and contribution to the task.

We appear to see a situation in which all members have equal rights and access to the tabletop. Our users appear to have created an environment where 'everywhere is a public space' with no one 'owning' a particular area. This contrasts with Nacenta et al. [9] which showed that for a direct touch technique ('drag-and-drop'), movement patterns of objects was "highly regionalised": users worked within the area that was closest to them and less on the public or group area, as also highlighted by Scott et al. [11]. However from our observations, the territorial organization of activities was something that was more dynamically achieved. They moved around the table to work in close proximity to each other, responding to particular task and social dynamics. They seemed comfortable working within close proximity of one another rather than adopting more controlled and regionalized areas of the table. The blocking activities [cf. 7] observed were not so much a question of protecting space or ownership but were enacted in the context of controlling the organisation of the task.

Another possibility for such behaviour was the non-visible existence of a group leader. Part of the role of a group leader is to plan and coordinate the group's activities, creating another layer of organisation [1]. Perhaps in the absence of a designated group leader the children perceived themselves as equally important assets to the group management. They would work closely together before dispersing back to work independently in the space in front of them. Perhaps working within close contact of each other allowed them to be more aware of what each other was doing and to contribute to this.

So, if we accept that users took an 'equal' role in group organisation, this allowed: 1) that they could move the same object simultaneously and 2) everywhere on the surface to become a public space. From a design perspective, it is worth considering that a group, rather than an individual, attitude to organising the performance of tasks may be of value to these children when collaborating around interactive tables. As we see, they are able to work within close proximity of each other with ease and also agree to move objects from one location to another through an informal shared understanding. The children exhibited natural forms of group behaviour and collaboration, even without personalised applications designed to enable these effects. It is possible that applications and techniques that require children to focus on one area of the tabletop instead of anywhere within that space may hinder group values that already exist within the children. Perhaps designers of interactive tables may wish to consider collaborative applications and interaction techniques that foster and enhance such qualities in group learning.

5.2 Multi-finger Touch Technique

As the children had little previous exposure to multi-touch technologies (smartphone, tablets, etc), interacting with the digital tabletop was a new experience. It is possible that they employed these touch input techniques as it was their first time using the technology. They applied techniques that seemed natural to them, and were not just limited to the index finger when manipulating digital objects. They used their thumbs, middle and little fingers as well as all five fingers on the hand to touch and move objects and to draw lines (Figures 2a-c). Vennelakanti et al. [12] showed that participants generally utilised their index finger and index-thumb combination when performing actions such as pointing, adjusting and rotating objects. In another study by Marshall et al. [7] children in United Kingdom were seen touching and moving digital objects using their index finger. Both studies highlight the index finger as the main interaction finger when touching and moving digital objects. This is in contrast to the more varied types of finger interactions and manipulation in our study. Our study findings compare more closely to those of Mansor et al. [6] who showed that young children (aged 3-4 years old) utilised thumb and middle finger, speculating that such interaction technique helped objects stick easily on the young children's fingers leading to better movement on the digital object. It is therefore possible that using the thumb, middle and little fingers are types of object interaction technique exhibited by children who: 1) are new to interactive table and encountered it for the very first time, and 2) wanted to leverage the usage of other fingers (apart from the index finger) to aid with the movement of the digital objects. From a design implication perspective, it is worth noting that as the children tended to interact with digital objects this way in both the direct touch and pantograph techniques. Enforcing certain types of interaction techniques on the tabletop without first understanding how the 'natural' techniques are used by children may interrupt the organic flow of digital object interaction, and potentially affect how they go on to communicate and collaborate around them.

6. CONCLUSION

Our findings aim to highlight how the children in one school in Delhi, India interact with digital objects when collaborating around interactive tables for a peer-learning task. We have highlighted how simultaneous interaction with objects plays an important role in the demonstration of learning and knowledge. That is, within these tasks, the issue is not simply for the group to get a correct answer but rather there is also an important concern

for individuals to demonstrate their understanding to one another. We have also highlighted some of interesting spatial dynamics with respect to how collaboration was organized. This organization was often much less territorially regionalized than the existent literature would suggest. Rather, spatial positioning and close working were dynamically and opportunistically used to enable some form of on-going participation between individuals. The factors affecting this were both physical (getting to a position from which they could touch a relevant object) and social (getting to a position where they could meaningfully join a particular subgroup). The children also used multi-finger input techniques outside the standard index finger input when touching and moving objects and drawing lines. To summarize, we have aimed to extend our understanding of peer group collaborative learning strategies around interactive tables by considering them within the context of an Indian school. Our findings point to some interesting ways to think about the role of multi-touch and the spatial arrangements of collaboration within these contexts.

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